

APPENDIX D
SAMPLE ROCK ANCHOR SPECIFICATION

D-1. Applicable Publications. Applicable references are listed in Appendix F.

D-2. Materials.

a. Rock Anchors Perforated Sleeve-Type shall consist of one pair of perforated steel half-sleeves, filled with portland cement mortar tied together to form one sleeve extending from the bottom of the drilled hole to the rock surface at the final excavation line and one steel deformed rebar, end ground to a bullet nose for ease of driving. The anchors shall be No. 8 deformed bars with 1-1/4-inch-diameter steel half-sleeves and No. 10 deformed bars with 1-3/4-inch-diameter half-sleeves. Sizes shall be as indicated on the drawings. The perforated half-sleeves shall be similar and equal to units as manufactured by the Sika Chemical Corporation, Perfo Division, Passaic, New Jersey. The rebar shall extend, without splicing (coupling or weld) from the collar of the hole at the final excavation line to the bottom of the drilled hole. Thread extension shall be provided where indicated, or as directed by the contracting officer. Rock anchors shall be recessed from a rock surface other than at the final excavation as indicated on the drawings or as directed by the contracting officer. Deformed rebar shall conform to ASTM A 615,²⁵ grade 40.

b. Groutable Rebar Type shall be of the various sizes shown. Rebars shall conform to ASTM A 615,²⁵ grade 40, with bottom end shaped to a bullet nose for ease of driving. The length of the bar shall be such that it will extend without splicing to the bottom of the drilled hole and shall protrude beyond the rock surface with either (1) standard ACI hook end for embedment in concrete or (2) a sufficient distance for the proper attachment of metal plates and shapes as shown. The ends of bars to which metal shapes are to be attached shall be threaded 6 inches and approximately 1 inch of thread shall project beyond the finally installed nut.

c. Cement shall conform to Federal Specification SS-C-192g,⁷ Type III. The cement shall meet the requirements for low alkali and for control of false set contained therein.

d. Reinforcement Bars shall conform to ASTM A 615,²⁵ grade 40.

e. Bearing Plates shall be of steel conforming to ASTM A 36,²² with holes for installation over rock bolts and for accommodating grout and vent tubes, where necessary. Bearing plates shall be 8 inches by

8 inches by 3/8 inch for rock bolts or rock anchors and 8 inches by 8 inches by 1/2 inch for 1-3/8-inch tie bolts.

- f. Hex Nuts shall conform to ASTM A 307,²³ grade B, heavy duty.
- g. Flat Washers shall conform to ASTM A 325,²⁴ quenched and tempered to a Rockwell hardness of C38 to C45. A quenched and tempered flat washer shall always form the seat for a heavy-duty hex nut.
- h. Bevel Washers shall be ASTM A 36²² steel, circular, standard slope, and minimum diameter to accommodate hardened flat washer above.
- i. Thread Lubricant shall be a molybdenum base lubricant, similar and equal to Molykote as manufactured by Alpha Molykote Corporation, Stamford, Connecticut, or Molub-Alloy 298 as manufactured by Imperial Oil and Grease Company, Inc., Los Angeles, California.
- j. Grout and Vent Tubes shall be semirigid polyvinyl chloride or polyethylene plastic tubes 3/8-inch OD and 1/4-inch ID, or larger, at the contractor's option.
- k. Water for mixing mortar and grout shall be fresh and free from injurious amount of oil, salt, acid, alkali, organic matter, or other deleterious substance as determined by Corps of Engineers Specification CRD-C 400.¹⁸
- l. Fluidifier Admixture shall conform to Corps of Engineers Specification CRD-C 566.¹⁹
- m. Fly Ash shall conform to Corps of Engineers Specification CRD-C 262,¹⁷ Type F.
- n. Quick-Setting Mortar Mix for packing collar of drill hole and forming base for bearing plates shall be a mixture of Type III portland cement, sand, quick-set admixture, and water or an approved proprietary quick-setting cement and water that mixed will produce a quick-setting mortar with the necessary handling properties and of sufficient strength to resist grouting pressures and stressing of rock bolts. (Sika-Plug as manufactured by Sika Chemical Corporation, or Wil-Kwik-Set manufactured by Williams Form Engineering Corporation will meet these requirements.)
- o. Sand for mortar or for grout, if a sanded grout mix is required, shall conform to Federal Specification SS-A-281b,⁶ Class 1, except that the gradation shall be as specified herein. Particle shape shall be generally rounded or cubical. The sand shall be well graded

from fine to coarse within the following limits:

<u>Sieve Designation</u> <u>(U. S. Standard Square Mesh)</u>	<u>Cumulative Percentage</u> <u>by Weight Passing</u>
No. 8	100
No. 16	95 - 100
No. 30	60 - 85
No. 50	20 - 50
No. 100	10 - 30
No. 200	0 - 5

D-3. Certificates. The contractor shall submit certificates of compliance, in accordance with Special Provisions, attesting proof of compliance with the specifications prior to delivery of the certified material to the project site. Certificates are required for the following materials: reinforcing steel, cement, sand, bearing plates, washers (flat and bevel), and nuts.

D-4. Planned Installation Pattern for Rock Anchors. The planned installation pattern, sizes, and lengths of the rock anchors and recessed rock anchors is indicated in the drawings. Rock conditions encountered as the work progresses may require the actual pattern, sizes, and lengths to vary from the planned installation indicated and the specific location, attitude, size, and length of each rock anchor is subject to adjustment in the field by the contracting officer. In those instances where the rock condition in or behind the burden of the trim cut is such as to be hazardous, prebolting using safety bolts of adequate size and length shall be temporarily installed for the safety of the workman and/or recessed rock anchors shall be installed through the burden where deemed necessary for stabilizing the excavation and as approved or directed by the contracting officer. Safety bolts shall be removed or tension released before shooting the trim cut. Rock anchors in addition to those shown in the drawings shall be installed as directed by the contracting officer.

D-5. Test Program.

a. Test Section. At a time prior to any underground excavation, the contracting officer will designate a test section in the south access tunnel representative of the rock to be bolted for conducting a test program designed to provide data for installing rock bolts and rock anchors. Test locations will be approximately 4 feet above the tunnel invert. The contractor shall notify the contracting officer a minimum of 7 days in advance of starting the test program. A representative of the contractor in charge of installing rock anchors

shall witness and actively cooperate in conducting the tests. The installation of the rock anchors for the tests and the tests shall be performed in the presence of a representative of the contracting officer. The test program will consist of:

b. Rock Anchors, One End Threaded.

(1) The contractor shall furnish eight No. 10 by 10-foot-long and four No. 10 by 16-foot-long threaded rebar Perfo sleeve rock anchors complete with bearing plate, bevel and flat washers, and hex nut representative of the units proposed for use in the work. Units shall be installed as specified hereafter to include the Perfo sleeve and mortared-in rebar, but no recess is required. The contractor shall install eight No. 10 by 10-foot-long and four No. 10 by 16-foot-long rock anchors using the specified mix for rock anchors unless the mortar mix is varied by the contractor, with approval of the contracting officer. The tests should demonstrate that bars can be driven full length through the mortar, with the mix selected, within a time frame consistent with that required by the contractor during the pattern installation of recessed rock anchors and that rock anchors will be capable of providing positive reinforcement to the rock behind the trim round before the trim round is fired. The Government will bed the contractor-furnished bearing plate in quick-set mortar and, with a center-pull hydraulic jack, conduct tests on individual anchors at 2, 3, 4, and 5 hours following installation to the yield load of the anchor, if possible.

(2) Considering the above test results the mortar mix can be varied by the contractor, with approval of the contracting officer and with the installation and testing of four No. 10 by 10-foot-long and one No. 10 by 16-foot-long rock anchors accomplished to verify the revised mix. The final mortar mix and installation procedures to be used in the work will be based on the results of these tests. After the final mortar mix is selected the remaining rock anchors will be installed and tested to verify the final mix. Each rock anchor in the test pattern will be included for payment as a 16-foot-long pattern rock anchor installation and shall include the furnishing, installing of the bolt, and cutting off of satisfactory bolts.

D-6. Drilling Holes. Holes for the installation of rock anchors shall be drilled into the rock to the lengths as shown on the drawings or as directed and to such inclination as will permit anchoring generally normal to the rock surface, except when otherwise indicated or as directed. All drilled holes shall be blown clear with compressed air, minimum of 50 psi introduced at the back of the hole, upon completion of drilling. In addition, all horizontal and downwardly inclined holes

shall be blown clean immediately before installation of the anchor. Size of drilled holes for rock anchors of the perforated sleeve type shall be 1-1/2 inches in diameter for the No. 8 deformed bars and 2 inches in diameter for the No. 10 deformed bars for the length of the mortar filled sleeve and may be larger in diameter for the recessed portion between the rock face and the final excavation line indicated on the drawings. The diameter of the drilled hole mortar filled sleeve area shall be checked with a hole gage and all holes exceeding the recommended diameter by more than 1/16 inch will be considered outside and not acceptable. Such holes shall be redrilled or replaced with a new hole at no additional cost to the Government. The hole shall be accurately drilled to ensure that the bar and mortar filled sleeve, when installed as specified hereafter, will completely fill the hole and will provide a tight bond of extruded mortar between the bar and the adjacent rock in the hole.

D-7. Installation of Rock Anchors. Rock anchors of the perforated sleeve type shall be installed as recommended by the manufacturer of the perforated sleeves subject to the following modifications: (a) mortar for packing the sleeves of recessed rock anchors when a short mortar set time is desirable, shall be a mixture of one part Type I or Type II portland cement, one part sand, and sufficient water and admixture to produce a mortar with a flow of approximately 85 percent when tested in accordance with Corps of Engineers Specification CRD-C 116-16¹⁶ Admixture shall be "Sika Set," as manufactured by the Sika Chemical Corporation, or equal. The admixture shall be added to the mixing water in a ratio of one part admixture to five parts water or as modified in accordance with results of tests outlined in paragraph "Test Program." Mortar for packing sleeves of rock anchors located at distances greater than 50 feet from the nearest round being fired, or where a grout setting time of 2 days minimum can be allowed when located at distances less than 50 feet from the nearest round being fired, shall consist of Type III portland cement and sand in the ratio of 1 to 1 by weight and Interplast-C powder added at the rate of 1 pound of powder per sack of cement and sufficient water to produce a mortar with a flow of approximately 85 percent when tested in accordance with Corps of Engineers Specification CRD-C 116-16¹⁶ (Note: A satisfactory mix is one which will stick together on being molded into a ball by slight pressure of the hands and will not exude free water but will leave the hands damp.) All mixing, packing, and bar driving operations shall be coordinated so that no delay occurs in the process. Any mortar which commences to set or appreciably changes consistency before bar inserting operations are complete shall be completely removed from the sleeves and holes and discarded. Retempering of mortar will not be permitted. Each one-half sleeve shall be packed full with a convex surface on the mortar to assure sufficient material to completely fill the drilled

15 Feb 80

hole during insertion of the rebar, (b) copper wire (gage as required) shall be threaded across the Perfo sleeve a few inches from the collar end forming a stop for placing the rebar. After the packed sleeve is inserted to the maximum depth possible, the rebar shall be placed against the copper wire stop and the entire assembly pushed to the back of the drilled hole, after which, drive the rebar into the sleeve, breaking the copper wire stop and displacing the mortar. Care must be taken to assure that the sleeve does not bind in the hole causing the rebar to punch through the wire stop and sleeve before reaching the back of the hole. The contractor may revise this procedure at no additional cost to the Government as approved by the contracting officer. Rock anchors with plates, as directed by the contracting officer, shall have a quick-set mortar seal and pad placed in the collar of the hole as indicated in the drawings. Bevel washers shall be used to limit the maximum thickness of the quick-set mortar pad to less than 2 inches. Bearing plate and hex nut shall be installed with the nut hand wrench to a tight, solid fit.

D-8. Installation of Groutable Rebar Type Anchors. These anchors are the grouted rebar type and sizes, lengths, and locations are indicated in the drawings. When anchors are to be installed in tunnel invert up to 30 degrees from vertical the hole shall be blown clean and filled with grout. The anchor shall then be pushed or driven through the grout to the bottom of the hole. When anchors are to be installed in walls or tunnel crowns, the grouting of the annular space around the rebar shall be as follows:

a. A plastic tube shall be inserted in the drilled hole the full depth, less 2 inches, by taping the tube to the rebar at approximately 2-foot intervals before the bar is inserted in the hole.

b. The tube shall be left in place and the projecting end cut off flush with the collar of the hole after completion of grouting.

c. For up-holes, a short plastic grout injection tube, together with the long vent tube, shall be sealed in the collar of the hole with quick-setting mortar. For horizontal and down-holes up to 60 degrees from horizontal, the short plastic tube shall be the vent tube and the long tube shall be used for grout injection.

d. Rebar shall be rigidly supported until grout hardens.

e. For bars with hook ends, after the grout has hardened for 4 days, the protruding end of the bar may be bent to shape shown. Heating of rebar for bending shall be controlled by approved means so as not to damage the rebar. Each rebar must be approved by the

contracting officer before it is bent in a hook.

D-9. Measurement and Payment.

a. General. The contract prices for the various items under this section shall constitute full compensation for furnishing all materials, labor, tools, equipment, and incidentals necessary to accomplish the work herein, including cleanup of the area and disposal of waste water and grout.

b. Rock Anchors, perforated sleeve type, without bearing plate, bevel and flat washers, and hex nut will be measured by the unit each for each of the various lengths and sizes involved and will be paid for at the contract unit price each for "Rock Anchors-Perfo Sleeve Type" to include drilling of the hole and complete installation of the anchor. The 1-1/2-inch-diameter holes for recessing the rock anchors, where required, will not be separately measured for payment but will be considered a subsidiary obligation of the contractor included under the applicable Rock Anchor-Perfo Sleeve Type item.

c. Rock Anchors, Perfo type with bearing plate assembly, including bevel and flat washers and hex nut, indicated on the drawings as a substitute for an expansion shell rock bolt in problem areas, will be measured and paid for, on a size for size basis, as a "Rock Bolt, Hollow Bar Groutable Type."

d. Rock Anchors, Groutable Rebar Type will be measured by the unit each for each of the various lengths and sizes involved and will be paid for at the contract unit price for each length and size of Rock Anchors-Groutable Rebar Type to include drilling of the hole and complete installation of the anchor.

D-10. Quality Control. Quality control on untensioned rock anchor installation is more difficult than for expansion shell or slot and wedge rock bolts since a tensioning load is not applied during installation. On the Norad Project, as shown in the sample specifications above, the quality control was started by requiring a test program prior to any underground excavation. The purpose of such a test program is to have the workmen demonstrate to the contracting officer that they are capable of installing the anchors satisfactorily and to develop proficiency in installation methods. Since the test program is closely monitored by the contracting officer's representative in cooperation with the contractor, it is possible to educate the workmen on the importance of good workmanship and attention to details in achieving the best possible results. After the test program is over it is the

EM 1110-1-2907

15 Feb 80

responsibility of the contractor to continue to use the best techniques developed in the test program. Although it was not required on the Norad Project, since the anchors were used primarily in the crowns of only two chambers, on a lengthy project there is merit in considering a requirement for random pull tests during construction to ensure that the anchors are being installed as in the test program.